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MONTANA ENERGY CONSERVATION PLAN

Working Paper No. 2

COMMERCIAL ENERGY CONSERVATION

A Report to the
Montana Energy Advisory Council

Prepared for

The Montana Energy and MHD Research and Development Institute, Inc.
Butte, Montana

By

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2.0 COMMERCIAL SECTOR

2.1 Use Patterns

The energy use in the commercial sector accounts for 14.9% of the energy used in the state of Montana (F.E.A., 1976). The F.E.A. tallies 39.4 trillion Btu's per year in this sector in 1974; other estimates range from 35.6 trillion to 40.0 trillion. This inconsistency is brought on by the practice of defining the commercial sector as all non-industrial, non-residential, and non-transportation energy uses. Thus, many anomalous end uses, such as road oils, bottled gas for welding, and sewage treatment, are included in the commercial sector. Table 2.1 compiles this compendium of end uses from F.E.A. data, and the Synthetic Natural Gas Demand Study (Jones, et al, 1976), the State of Montana statistics (MEAC, 1976), and the analysis presented in this sector.

Table 2.2 presents the thermodynamic quality demanded by the end use. The low temperature heat described here is substantially space and water heating and air conditioning with some construction uses. The medium heat uses are substantially cooking, with some commercial cleaning and other uses. The liquid fuels are road oils and transportation related use, especially in the construction industry. Electricity uses are lighting, refrigeration

and some other uses, especially arc welding and motors. It is important to note that 89% of the electrical usage is mandatory electric; the remainder, use for space heating, air conditioning, water heating, and cooking, is properly classified as a heat usage in which the high grade electrical energy is converted to lower grade heat.

2.1.1 Energy Use in Buildings

The problematic nature of the definition of the commercial sector makes a rigorous analysis difficult. The analysis presented here will focus on the low grade heat and electricity needed to run the buildings, services, marketing, etc., which form the basis of this sector. Government buildings and institutions, (schools, prisons, etc.) are included in this sector. The analysis will be presented based on the breakdown in Table 2.3.

These classifications eliminate virtually all the transportation and construction uses in the commercial sector. Low grade heat accounts for 72% of the energy use defined as the commercial sector by F.E.A. and others. This formulation attempts to eliminate spurious energy uses such as road oils and other construction use which can be analyzed elsewhere. These areas largely depend on transportation-type energy use. Enhanced efficiencies in the commercial sector will impact these uses. However, this analysis will require further study of Tables 2.4 and 2.5 which summarize the base line energy assumption for this sector.

2.2 Energy Use in the Commercial Sector

Energy use in the commercial sector illustrates the effect of relatively cheap energy on building form and design standards. Mechanical engineering has been dominated for the last 40 years by considerations of comfort and ambience (Hayes, 1976). While this undoubtedly has had some positive effect on the habitability of commercial buildings, it has also had a negative effect on energy use in the commercial sector.

2.2.1 Lighting

The use of lighting as a marketing tool both in displays and in retail space to enhance visual quality has required a lighting level which greatly exceeds that necessary to function, and often lends some discomfort (S.O.M., 1976). The magnitude of the potential savings by curtailment or reduction of lighting in the commercial sector is well documented in the Los Angeles experience of '73-'74 (Acton, et al, 1974). In this case, the overall energy use in the commercial sector was reduced 20-30%, largely by reduction of lighting demand in commercial structures.

2.2.2 Space Heating & Cooling

The thermal performance of commercial buildings has traditionally been traded off against the psychological value of large window areas. The effect of these design criteria is to make office and government buildings less thermally efficient as well as to make drafts and infiltration more difficult to control (ASHRAE, 1972).

TABLE 2.3

Energy and Employment by Building Type

	Employment (000)	Energy 10^{12}BTU	Sq. Ft. $X10^{7}$	Energy/sq. ft. 10^{5}BTU
Retail Trade	47.6	10.5	3.0	3.5
Retail Service	33.0	7.4	2.4	3.1
Wholesale Trade & Service	11.9	1.4	1.2	1.2
Office & Related Service	43.0	6.2	3.0	2.1
Government, Education, Institutional Service	27.3	4.0	1.6	2.5
Total	162.8	29.5	11.2	

Table 2.4
Energy Use in the Commercial Sector
(10^{12} BTU)

Fuel:	Total (%)	Gas	Elect.	Oil	Coal	LPG
End Use:						
Space Heat	14.6 (49.5)	10.2	.1	2.9	1.2	.2
Air Cond.	3.8 (12.9)	3.2	.6			
Water Heat	.5 (1.7)	.4	.1			
Lighting	8.2 (27.8)		8.2			
Refriger.	1.0 (3.4)		1.0			
Food Prep.	1.2 (4.1)	1.0	.1			.1
Other	.2 (.7)		.1	.1		
Total	29.5	14.8	10.2	3.0	1.2	.3
Percent	(100)	50.2	34.6	10.1	4.1	1.0

Table 2.5

Thermodynamic End Use

	10^{12} BTU	%
Low Grade Heat	18.9	64.1
Medium Grade Heat	1.2	4.1
Electrical	9.3	31.5
Liquid Fuel	.1	.3
Total	29.5	100.0

The use of insulation has been minimal until recent years. The addition of several inches of insulation and double glazing can greatly upgrade the thermal performance (ASHRAE, 1976). The use of solar orientation and other climatological design has not received much attention, resulting in window placement which further increases heat loss in the winter, while in the summer collecting solar heat which must be tempered by air conditioning equipment. The development of standards which allow the available solar energy to warm the building in the winter while providing shading in the summer can have a sustained impact on overall heating and cooling energy needs (Thompson, 1976). The Montana solar climate suggests that this would provide year-round advantages.

2.2.3 Refrigeration

The need for coolers in food processing accounts for 5.4% of the energy use in the commercial sector in Montana. The present conditions and design standards in this area suggest that great improvements could be made. Open coolers, for example, use 20-25% more energy than closed display lockers (N.E.T.L. et al, 1976). Furthermore, waste heat extracted in the cooling process is generally exhausted to maintain adequate compressor operating conditions. This heat could be directed away from operating compressors and provide extra heat for the building. The overall effect of programs in this area could have a substantial effect on the demand for electric energy in supermarkets,

grocery stores, and commercial food storage warehouses.

2.3 Energy Use in Commercial Buildings

The commercial sector, for purposes of this analysis, will be considered in 5 sections: retail trade, retail services (S.I.C., 52-59), wholesale trade (S.I.C., 50-52), office related services (financial, real estate, professional services, etc.), and government/institutional (government, education, prisons, hospitals, etc.). Table 2.3 presents these functions and their attending employment, energy use and space requirements.

2.3.1 Retail Trade

This sector is characterized by substantial energy use per square foot. A large proportion of energy is used as a marketing tool. Retail trade buildings use lighting at rates nearly twice the average of the commercial sector (S.O.M., 1976). This necessitates greater use of space conditioning to insure adequate comfort. The use of large expanses of glass, resulting in large heat losses, further increases the energy requirement for this sector. This glass area is also primarily used as a marketing device. The sector is additionally characterized by high ceilings and large air volume changes. This is in part due to the need to cool certain spaces, heated by large volumes of people and extensive lighting, while heating other spaces. Another extensive energy demand is caused by infiltration losses resulting from inadequate construction and traffic through doors which cause

warmed inside air to escape and be replaced by cold outside air. The result is much greater energy use for space conditioning than might be required if steps were taken to minimize this effect.

2.3.2 Retail Services

Retail services includes most repair shops, restaurants and hotel establishments. This sector uses energy in similar ways to the trade sector, although the use of lighting as a marketing tool is less crucial. Thus, the energy use per square foot is somewhat less than the trade sector. The use of energy for space conditioning here is more important; medium grade heat in the form of cooking energy is also required in this sector.

2.3.3 Wholesale Service

Wholesale service is the least energy intensive sector under study. The predominant feature of this sector is refrigeration with a secondary emphasis on space conditioning and lighting. The efficiencies in this sector are controlled by the equipment efficiencies. The use of motorized equipment and freight has been eliminated here to ascertain the building efficiencies alone.

2.3.4 Office and Related Services

This sector includes office-type buildings, ranging from small detached offices to larger multi-storied structures. The essential feature of these building types is the efficiency and effectiveness of the mechanical system design. Often these

buildings require simultaneous heating and cooling without reference to outside temperature. The resulting situation finds energy being used in one part of the building to extract heat and exhaust it to the outside air, while in another portion of the building, energy is used to produce heat, and energy is used to pump that heat to warm the cooler spaces.

2.3.5 Government/Institutional

This sector, which includes government offices, hospitals, prisons, and schools, uses energy in widely diverging ways. The offices use energy in ways similar to the private office sector (indeed, the analysis of large scale office structure appears to apply directly). Schools use energy only 9 months of the year, resulting in substantial reduction in overall energy use per square foot. Other institutions use energy in similar ways but on a year-round basis with little or no cooling energy. Hospitals use energy at enormous rates in relation to other institutions and exceed all other institutions. However, much of this energy use for hospital space conditioning follows similar patterns.

2.3.6 Methodology

The methodology of this section centers on the development of "prototypical" or "test case" buildings which exemplify energy use in these building types. These model buildings are then analyzed using a simplified computer analysis to determine heat loss, heat gain, heating, electrical, and air conditioning requirements (ASHRAE, 1972). These base line assumptions are presented in Table 2.6.

The models were "constructed" to be prototypical types common in Montana. The classic commercial office structure is a 1 or 2 story office in a small to medium size building. However, in urban areas, larger buildings are more prevalent. They must be evaluated separately because they use energy differently.

The retail sector is also dominated by small shops, groceries, etc. However, the trend toward shopping centers will lead to future development of the 15,000-30,000 sq.ft. facilities. The lighting assumed is common for the 1960's; newer buildings have experienced lesser lighting loads. In the case of refrigeration in grocery stores, it is assumed that compressor heat contributes to heat gains,and heat extracted from the coolers is exhausted to the outside.

The school building model is based on standards common for the 50's and 60's, requiring large contributions of natural light. The use of large expanses of glass adversely affects the buildings' thermal performance. The model school is 35,000 sq.ft. (18 classrooms, service areas, cafeteria, corridors, etc.).

The analysis of small scale office buildings can be generalized to most small scale commercial activities. These uses dominate Montana's office sector energy use. However, with the advent of shopping centers, a greater consolidation appears to be likely. The large scale office building model is designed to reflect the requirement for simultaneous heating and cooling. This

building is divided into 5 zones; each zone is supplied heat or air conditioning on the basis of local thermostat and temperature demands. Each zone is independent, heat drawn from one zone does not recirculate to other zones. This building is dominated by heat gains from building occupants and lighting which must be compensated for by the mechanical systems.

Energy use in the wholesale space has been derived from the retail space using reduced heat and lighting requirements and no air conditioning.

TABLE 2.6 BASELINE ASSUMPTIONS
for Prototypical Buildings

I. Small Office Building

Area:	1500 square feet
Height:	11 feet
Dimensions:	30 x 50 (SW/NE axis) 30% windows
Slab on Grade:	24" perimeter insulation
(with heat coils in slab)	
Occupancy:	12
Infiltration & Ventilation:	550 CFM
"U" Factors:	Room .10 (1" rigid insulation)
	Walls .15
	Glass 1.1 (single glazed)
Lighting:	2.75 watts/square feet
Misc. Electrical:	.25 watts/square feet
Hot Water:	Electric @ 140°F
Gas Fired Boiler:	Heating @ .8 efficiency
	Cooling @ .95 efficiency

II. Large Office Building — 5 stories

Area (gross):	30,000 square feet
Roof:	6,000 square feet
Area (net) :	27,000 square feet
Zoning:	5 zones
Dimensions :	60 x 100 (SW/NE axis) 28% windows
Height :	60 feet (5 stories)
Occupancy :	100 sq. ft./person
Infiltration & Ventilation:	1500 CFM -- 1500 ventilation
	6000 infiltration
"U" Factors:	Roof .10
	Walls .15
	Glass 1.13 single glazed
Lighting :	4.0 watts/sq.ft.
Misc. Equipment:	.5 watts/sq.ft.
Hot Water:	Electric
Gas Fired Boiler:	.8 efficiency heating
	.95 efficiency cooling

TABLE 2.6 page 2

III. Retail Building

Area:	18,000 sq.ft.
Height:	20 feet
Dimensions:	120 x 150
Glass Ratio:	.4
Slab on Grade:	coils in floors, 24" perimeter insulation @ R-3
Infiltration & Ventilation:	3 air changes/hour
"U" Factors:	Roof .1 Walls .2 Glass 1.1
Occupancy:	1 person/100 sq. ft.
Lighting:	7 watta/sq.ft./ --13 hrs/day
Miscellaneous:	.5 watts/sq.ft./ -- 13 hrs/day
Water Heat:	Electric @ 140^{o}F
Gas Fired Boiler:	@ .8 efficiency heating @ .95 efficiency cooling (absorption)

IV. School

Area:	35,000 sq. ft.
Height:	12 feet
Dimensions:	250 x 160
Glass Ratio:	.5
Slab on Grade:	24" of insulation, R-3
Occupancy:	350 persons
Air Charges:	5.5/hr.
"U" Factors:	Roof .15 Walls .3 Glass 1.1
Gas Fired Boiler:	80% efficiency heating

2.4 Energy Conservation Options for the Commercial Sector

Three general options were devised for the buildings in the commercial sector and applied to the baseline energy use for each prototypical building. These options are: 1) established conservation standards (ASHRAE, IES, AIA, etc.); 2) more stringent standards which rely on heat recirculation and on more efficient equipment and buildings and the addition of solar heat; 3) a retrofit standard designed to suggest the potential energy savings from modifications which can be installed without major structural alterations.

2.4.1 Option I

The standards developed by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) in 1975 were used as the basis for this option. The standards are designed to be written into existing building codes or used as design standards by mechanical engineers and architects in building design. The standards themselves have been extensively criticized. However, they represent the most comprehensive attempt (to date) to explicate conservation strategies for general application in all localities. The standards call for a general upgrading of equipment used in heating, ventilating and air conditioning (HVAC) systems as well as improvements in thermal performance.

While these standards fall short of the potential efficiencies (see for example, A.I.P., 1975), the development of these standards will undoubtedly lead to a general increase in equipment

efficiency and attention to conservation in building and equipment design. A companion to this document is the IES lighting standards (IES, 1972). It attempts to describe workable standards for conservation lighting by optimizing light where required and reducing light levels where maximum ambient light is required.

These two conservation standards have already been adopted by some state and localities. The Principle features of these standards are:

2.4.1.1 Enhanced Efficiency of Thermal Envelopes

This set of standards and directives advances the standards for insulation to two or three times those common in Montana. The standards also encourage much less overall window area than is common in modern buildings; indeed, they virtually eliminate the possibility of window areas greater than 25-30% of the exterior surface.

The resulting thermal standards imply 1"-2" of additional insulation on the ceilings and walls, as well as an additional 2" around the buildings' perimeter. In addition, the amount of glass is reduced from 30% to 25% of the total wall area. The glass is assumed to be upgraded to double glaze.

2.4.1.2 Greater Resistance to Infiltration of Outside Air

The ASHRAE standards attempt to insure that air leakage be held to a minimum around doors and windows. Further reduction in infiltration losses can be realized by recirculating inside air and through the use of economizer cycles on equipment. This allows

small volumes of outside air to be climate treated. These standards could reduce infiltration losses by 75%.

2.4.1.3 Equipment Efficiency Standards

ASHRAE 90-75 mandates improved equipment efficiencies. These are defined in terms of "Coefficients of Performance." This refers to the amount of heat output relative to the amounf of heat or energy input.

The ASHRAE standards specify equipment C.O.P.'s efficiencies to be 25-30% above established practices. These specify cooling equipment to be rated with C.O.P.'s of 1.8 to 2.0 in 1977, rising to 2.0 to 2.2 in 1980.

These standards are below those possible; however, they will represent a substantial increase above present operating standards.

2.4.1.4 Lighting Standards

Lighting standards were designed by the Illuminating Engineers Society (IES) and provide for up to a 50% reduction in lighting levels and ambient light levels. Lighting levels in the prototypical building were lowered 30% in the individual use by the introduction of lower ambient light levels, task lighting, and reduced emphasis on lighting as a marketing tool.

2.4.1.5 Controls.

The ASHRAE standards provide for a greater flexibility in the control of a given HVAC system. A minimum number of thermostats are required (one per zone per floor). Also, night temperature is controlled by automatic or manual thermostat set back.

The criticisms of ASHRAE standards are threefold: 1) it is not stringent enough to require economically viable efficiencies; 2) it is not flexible enough to provide a range of solutions to the problems of energy use in buildings; 3) it considers solar and other renewable energy approaches as "add-ons" to an essentially fixed building type. As such, it makes little provision for solving energy problems using passive solar heat or other less conventional technologies.

2.4.2 Option II

Option two is designed to provide a more stringent set of standards which respond to those measures which are cost effective.

2.4.2.1 Insulation Standards

More stringent insulation standards are envisioned, requiring 50% more insulation in the ceilings, walls, and floors over ASHRAE 90-75.

2.4.2.2 Window Design

The window standards in ASHRAE are relaxed to incorporate the possibility of fenestration design, allowing passive solar heat collection through south-facing windows, and shading for high angle summer sun.

2.4.2.3 Heat Reclamation and Recirculation Systems and Equipment

Plenums and recirculation systems are used to minimize the amount of simultaneous heating and cooling.

In addition, heat generated using heat pump technology which provides for equipment efficiencies 87% greater than the gas boiler technologies. In addition, the cooling efficiencies are

upgraded by 18%. The system reduces the need for outside air through the use of internal recirculation systems, which further reduce the need for heat by reducing the amount of outside air needing to be climate conditioned to maintain the building's temperature.

2.4.2.4 More Extensive Controls

This would require thermostats on a room-by-room basis in addition to automatic night setback to minimize heat load during periods of no occupancy.

2.4.3 Option III

This option is designed to promote reasonable standards by which retrofits may occur without major structural changes. These standards include: 1"-2" of additional insulation in the ceiling, upgraded equipment efficiency and additional controls on the mechanical system to ensure optimum operation consistent with the requirements of the building's occupants. The standards are less than the ASHRAE standards but provide a cost effective guide for retrofitting existing buildings.

2.4.4 Option IV

This last option represents a substantial departure from the previous options. This option involves conservation by using the present resource supply more efficiently. In this option, the amount of commercial space per capita declines. The same space is used more efficiently to produce an increased volume of goods and services. In this option, the amount of commercial space is assumed to remain constant while the population grows.

2.4.5 Analysis of Conservation Strategies

These four technical conservation options are applied to the prototype buildings to ascertain the energy saving potential of these strategies. The assumed input values for each conservation option are presented in Table 2.7. The following general assumptions were made in the development of each option.

2.4.5.1 8000 Heating Degree Day Climate (Great Falls-Helena)

This was adjusted to account for the fact that the buildings are operated only certain hours of the day. The analysis used a higher average temperature than the weather service. The result was an 18% reduction in the overall heat requirements.

2.4.5.2 350 Cooling Degree Days

2.4.5.3 Great Falls Solar Data Collected by the Weather Service

This data was adjusted to account for solar radiation on a vertical window and for the number of layers of glass which were assumed.

2.4.5.4 A 243 Heating Season and an 80 Day Cooling Season

The buildings were assumed to operate 16 hours a day in the baseline condition, although the introduction of sensitive controls in the conservation option was assumed to reduce the effective heating or cooling hours to 14. The schools were assumed to be operating only 200 days, 12 hours per day with no cooling requirements or equipment.

Table 2.7

Small Office

	Base	Option I	Option II	Option III
"U" Roof	.1	.05	.03	.03
"U" Walls	.15	.08	.05	.1
"U" Glass	1.13	.6	.6	1.13
% glass south	.25	.25	.30	.25
airchanges	2.0	1.0	.7	1.5
slab/losses (BTU/ft.)	.81	.55	.55	.81
heat gain (BTU/Sq.Ft./hr.)	10.58	8.54	8.54	9.50
Electrical load (BTU/Sq.Ft./hr.)	10.0	7.64	7.64	9.0
Hot water temp (°F)	140	120	120	120
Heat Equip. Efficiency	.8	.8	1.5	.8
Cooling Equip. Efficiency	.9	1.7	2.0	1.7

Table 2.7a

Large Office

	Base	Option I	Option II	Option III
"U" Roof	.1	.05	.05	.08
"U" Wall	.15	.1	.1	.15
"U" Glass	1.13	.6	.6	1.13
% south glass	.27	.27	.3	.27
airchanges	1.25	.55	.55	1.00
heat gain BTU/sq.ft./hr	14.2 15.3	9.5	9.5	13.0
Elec. use BTU/sq.ft./hr	15.3	9.4	9.4	14.0
Heat Equipt. Efficiency	.8	.8	1.5	.8
Cooling Equipt. Efficiency	.9	1.7	2.0	1.7

Table 2.7b

Retail Building

	Base	Option I	Option II	Option III
"U" Roof	.1	.08	.05	.08
"U" Walls	.2	.13	.08	.13
"U" Glass	1.13	.6	.6	1.13
% south glass	.25	.25	.3	.25
airchanges/hr	3.0	1.0	.5	2.0
slab losses (BTU/ft/hr)	.81.	.55	.55	.81
Heat Gain (BTU/sq.ft/hr)	21.9	16.7	15.0	18.0
Electrical BTU/sq.ft./hr	30.69	17.7	14.5	25.00
Heating equip. Efficiency	.8	.8	1.5	.8
Cooling Equip. Efficiency	.9	1.7	2.0	1.7

Table 2. 7c

School

	Base	Option I	Option II	Option III
"U" Roof	.15	.08	.05	.1
"U" Wall	.3	.1	.08	.2
"U" Glass	1.13	.6	.6	1.13
% south glass	.25	.25	.3	.25
airchanges/hr	5.0	2.8	2.5	3
slab losses/ft	.81	.55	.55	.81
heat gain BTU/sq.ft./hr	12.18	10.82	10.82	11.60
electrical BTU/sq.ft./hr	10.23	8.53	8.53	9.50
Heating Equip. Efficiency	.8	.8	1.5	.8

2.4.6 Impacts of the Options:

2.4.6.1 Economic.

The cost of each option as applied to the prototypical buildings are summarized in Table 2.9. This table was derived using cost per square foot of labor and materials. These numbers generally reflect costs of materials and equipment available to contractors throughout Montana. It is important to point out that these costs will vary substantially over time and with respect to specific materials selected to execute a given option. Insulation and double glazing generally varied between $2.00-$3.00 per square foot installed, depending on the quantity of insulation, construction methods, and the required quality of materials (rigid versus batts). The bulk of the costs here relate to the purchase and installation of HVAC equipment and controls. These systems require a large capital outlay. The result is that large systems, such as large office and retail buildings, are much more capital intensive than smaller, less complex systems.

The cost/MMBTU is the lifecycle cost, assuming a 30-year life, a 9% interest rate, and with 1% per year maintenance included. The direct construction labor is the proportion of the dollar outlay that goes directly to wages in the construction of related industries. The direct manufaturing labor is the portion of the total costs which accrues directly to the fabrication or production of the materials required to execute the conservation strategy. This manufacturing could occur in Montana.

2.4.6.2 Impact on State Government

The development of energy conservation building standards would present a significant enforcement difficulty to those agencies presently responsible for the administration and enforcement of the state building code. Were such a code implemented, additional staffing would be required to: 1) train code officials in the deployment of the new conservation code; 2) insure compliance at the local level; 3) insure consistency between existing code requirements and future conservation requirements; 4) undertake to educate building industry professionals on the provisions of the code and the requirements set by the new standards.

Obviously, these provisions will require a certain amount of state funding to insure that the necessary staff and training are available during the transition to an energy-conserving building standard. ASHRAE suggests that this would require 3-5 years (ASHRAE, 1975).

2.4.6.3 Institutional Barriers.

The lack of information on the long term savings possible through conservation has served as the principal barrier to its implementation in the commercial sector. A substantial amount of publicity, coupled with a mandatory building standard, would probably yield results far above those anticipated. The real benefits of a cost effective building/energy conservation program will become obvious.

The burden of enforcement for an energy conservation code would fall on local building code officials. This could present them with a burden beyond the normal constraints of their jobs. No doubt education would provide part of the solution; however, these officials must be convinced of the social and economic disabilities of these before full benefits can be realized. This may require more highly trained professionals in these jobs and could put a burden on already under-staffed local building departments.

TABLE 2.8

Comparison of Energy Use In
Prototypical Buildings
(BTU x 10^6)

	Base	Option I	Option II	Option III
Small Office/shop				
Heating	158	51	18	111
Cooling	83	27	23	41
Electrical	80	55	55	62
Total	321	133	96	214
(% of base)	(100)	(41)	(30)	(67)
Large Office				
Heating	2196	840	81	1336
Cooling	2798	701	321	1076
Electrical	1834	978	978	1706
Total	6687	2518	1460	4118
% of base	(100)	(36)	(21)	(62)
Retail Building				
Heating	2215	257	32	1617
Cooling	1098	341	274	341
Electrical	2232	1289	1056	1855
Total	5545	1887	1362	3819
% of base	(100)	(34)	(24)	(69)
School				
Heating	4130	1303	514	1536
Cooling				
Electrical	678	564	564	626
Total	4808	1867	1078	2162
% of base	(100)	(38)	(22)	(45)

TABLE 2.9

Economic Impacts of Conservation Option

	Cost/ sq.ft. $	Cost $/BTU	Direct Construction Labor (%)	Direct Manufacturing Labor (%)
Small Office				
Option I	3.00	1.21	58	6
Option II	4.33	1.46	60	9
Option III	4.00	2.72	56	7
Large Office				
Option I	3.24	1.15	50	11
Option II	6.05	1.69	45	14
Option III	4.27	2.33	56	10
Retail Bldg.				
Option I	5.16	1.19	63	7
Option II	7.00	1.45	59	8
Option III	5.78	2.74	52	10
School				
Option I	2.32	1.24	66	6
Option II	3.91	1.66	64	8
Option III	2.57	1.52	66	6

2.5 Energy Conservation Strategies for the Commercial Sector.

The options have been divided into several combinations or strategies. These suggest a range of conservation options from increased standards with essentially volunteer programs to greatly increased standards with incentives and mandatory programs for maxmimum energy conservation -- including a reduction in the per capita floor space in the commercial sector.

2.5.1 Baseline

The baseline square foot growth in each sector is summarized in Table 2.10. This has been developed assuming a 1.7% annual growth in the employment sector, including government. This growth is assumed to be essentially uniform across each sub-area. A replacement rate of 1% per year is assumed for structures which existed in 1975. The buildings are assumed to use energy at the basis rate presented in Table 2.3. This base is carried forward to describe the expanded energy use given a continuation of present design practices and energy use patterns. This does not represent a projection but rather a point of reference for the evaluation of the the strategies and options presented. Table 2.11 presents the base line projections for each strategy.

2.5.2 Strategy I

Strategy I assumes the immediate implementation of ASHRAE 90-75 standards. In addition it assumes that the buildings built prior to 1975 are retrofit to meet the criteria proposed in

Option III at the rate of 1% per year. The ASHRAE standards would apply to all new buildings and all buildings undergoing a major structural and functional remodeling.

2.5.3 Strategy II

Strategy II assumes the immediate implementation of ASHRAE 90-75 as a minimum standard. In addition, a level of voluntary addition to new and existing buildings for solar heating is assumed. These additions account for a 30% increase in the solar gain in each building during the heating season, and a 30% decrease in solar gain (due to shading and other devices) during the summer. Of the new and retrofit buildings assumed in Strategy I, 30% are affected by this program by 1980. As in Strategy I, the retrofit rate is 1% of the 1975 building stock per year, and with new floor space added at the rate of 1.7% per year.

2.5.4 Strategy III

This strategy makes use of the more stringent conservation standards proposed in Option II. These standards could be phased in over a ten year period and result in 80% of the buildings built after 1975 meeting these expanded requirements by 1985. The remaining 20% were assumed to be built to the ASHRAE 90-75 standards in Option I. This program is also supplemented by a retrofit program providing incentives to upgrade energy performance in existing buildings, resulting in a retrofit rate of 2%/year.

2.5.5 Strategy IV

Strategy IV is identical to Strategy II with the addition of a projection of a .5% / year reduction in the amount per capita of commercial floor space. Thus the existing space and the new space would be used more intensively.

2.5.6 Energy Impacts

The energy impacts of these strategies is summarized in Table 2.11, and Figure 2.1. In the year 2000, for example, Strategy I would cause a 37% reduction in the energy consumption in the commercial sector, Strategy II a 39% reduction, Strategy III a 46% reduction, and Strategy IV a 53% reduction.

2.5.7 Economic Impacts

The overall economic effects are compiled and summarized in Table 2.12. These were derived using the square footage of commercial space, given in Table 2.10, and the cost and employment impacts, given in Table 2.9. The computations were made for the period ending in the year 2000. The jobs per year represent the average annual employment resulting from a conservation program. These numbers would remain essentially constant, and the implementation of conservation strategies would create and sustain employment at these levels indefinitely. This includes only direct employment in the State of Montana. These jobs would be both in the construction and manufacture sector and would have

an indirect employment effect of 3 to 4 times the direct employment impacts (S.O.M., 1975). Thus the total new jobs created by Strategy III would be 3100-4300 permanent jobs.

2.5.8 Other Impacts

Overall, these strategies could provide a positive impact on the environment by reducing the need for additional generation or extraction to meet needs of the commercial sector. However, conservation would require the use of resources and require a greater percentage of electrical energy to run efficient HVAC equipment. The end use and thermodynamic breakdown represented in Table 2.13 assume the implementation of Strategy IV.

Table 2.10

Projections for Square Foot of Various Commercial Space

(10^7 square feet)

	1975	1980			1990			2000			2010		
		1975*	New	Total	1975	New	Total	1975	New	Total	1975	New	Total
Retail & Service	5.4	5.2	.7	5.9	4.8	2.4	7.0	4.0	4.2	8.2	3.5	6.2	9.7
Whole-sale	1.2	1.1	.2	1.3	1.0	.5	1.5	.9	.9	1.8	.7	1.4	2.1
Office	3.0	2.9	.4	3.3	2.4	1.3	3.7	2.3	2.3	4.6	1.9	3.5	5.4
Govt & Instit.	1.6	1.5	.2	1.7	1.4	.7	2.1	1.2	1.2	2.4	1.0	1.9	2.9

* square footage of space -- built before 1975 and still in use for given year (i.e. 1980).

Table 2.11

Energy Use Given Strategy Outlines

Year	Strategy	Retail	Wholesale	Office	Instit.& Gov't.	Total
1980		17.9	1.4	6.3	4.0	29.6
	Base	19.5	1.5	6.9	4.2	31.7
	1	17.7	1.4	6.3	3.8	29.2
	2	17.6	1.4	6.3	3.8	29.1
	3	17.2	1.4	6.1	3.7	28.3
	4	16.8	1.3	6.0	3.6	27.7
1990	Base	23.1	1.8	7.8	5.2	37.9
	1	17.1	1.4	5.8	3.9	28.2
	2	16.9	1.4	5.7	3.8	27.8
	3	15.8	1.3	5.3	3.4	25.8
	4	14.7	1.3	4.9	3.1	23.9
2000	Base	27.1	2.1	9.7	6.0	44.9
	1	16.8	1.5	6.2	3.9	28.4
	2	16.4	1.4	6.1	3.6	27.5
	3	14.8	1.3	5.3	3.0	24.4
	4	12.9	1.1	4.6	2.6	21.2
2010	Base	32.0	2.5	11.3	7.2	53.0
	1	17.1	1.5	6.3	3.9	28.8
	2	16.7	1.4	6.0	3.7	27.8
	3	14.4	1.2	5.0	2.8	23.4
	4	11.9	1.0	4.1	2.3	19.3

Table 2.12

Projected Costs for Energy Conservation Strategies for the Year 2000

	Strategy #1			Strategy #2			Strategy #3			Strategy #4		
	Total cost million $	Cost /yr million $	Job /yr hundred $	Total cost	Cost /yr	Job /yr	Total cost	Cost /yr	Job /yr	Total cost	Cost /yr	Job /yr
Retail	274	11.0	445	298	11.9	478	394	15.8	623	345	13.8	544
Wholesale	26	1.0	42	33	1.3	55	53	2.1	89	46	1.8	77
Office	95	3.8	152	105	4.2	167	147	5.9	231	129	5.1	200
Gov't & Instit.	39	1.6	64	48	1.9	76	71	2.8	115	61	2.4	97
Total	434	17.4	703	484	19.3	776	665	26.6	1058	581	23.1	918

Table 2.13

Thermodynamic End Use
(Strategy IV)

	BTU x 10^{12}	percent
Low Temperature Heat*	9.8	41.0
Medium Temperature Heat	2.1	8.8
Electricity	12.0	50.2

* Equipment efficiencies have been removed to reflect the actual heat requirements. Given electrically operated heat pump equipment, this demand falls to 7.1 x 10^{12}BTU.

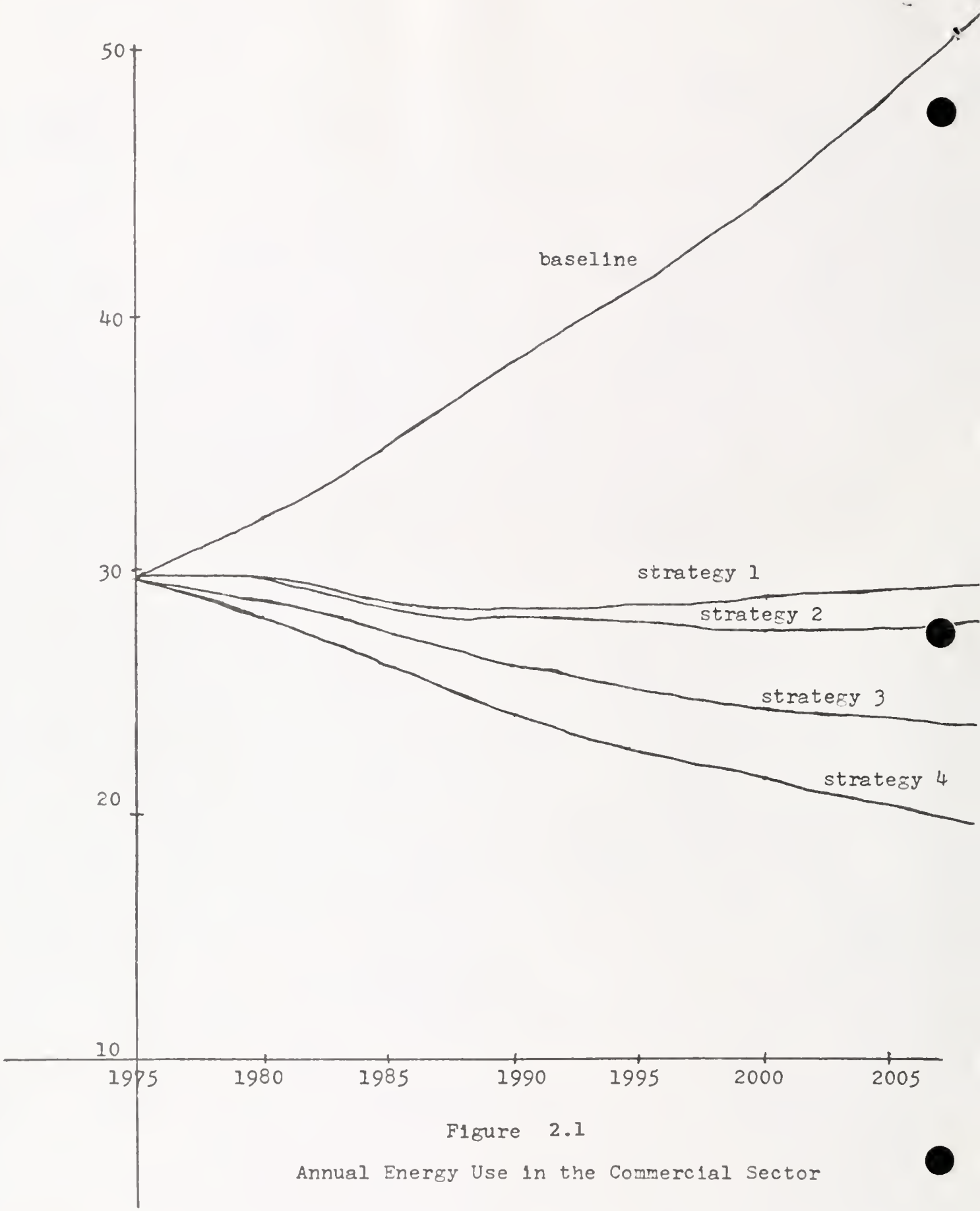

Figure 2.1

Annual Energy Use in the Commercial Sector